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SPECIFICATION

CORELESS AC LINEAR MOTOR, AND MANAUFACTURING METHOD THEREOF

Technical Field

The present invention relates to a coreless AC linear motor. More particularly, it relates to a coreless AC linear motor used in a clean room or in a vacuum in, for example, a semiconductor manufacturing unit or a manufacturing unit of substrate for liquid crystal display, and to a manufacturing method thereof.

Background Art

A coreless AC linear motor capable of generating large thrust and having no cogging ascribable to a core is suitable for a machine tool, a semiconductor manufacturing unit and a liquid crystal display substrate manufacturing unit all of which require accurate positioning. Generally, a coreless AC linear motor includes a pair of parallel side yokes to which a number of field magnets are fixed, and a number of coreless coils arranged in a straight line between the pair of side yokes. The plurality of coreless coils are formed into a flat plate-shaped block covered by resin. A coil assembly formed in this way moves maintaining a small air gap with respect to the rows of field magnets. With a semiconductor manufacturing unit or a liquid crystal display substrate manufacturing unit, a coreless AC linear motor is used in a vacuum vessel. Under these vacuum conditions there is a known problem of gas being emitted from the coil assembly accompanying heating, called outgas. Gas is emitted from, for example, resin, cables and enamel. These outgases contaminates the vacuum environment and causes a lowering of device performance. For

example, the outgased components attach to the lens surface of an electron microscope, and become burnt on to the surface of a sample or product. Japanese utility model laid-open No. 6-41381, and 6-70484 disclose a coil assembly housed inside a can in order to prevent this type of outgas. Normally, a can is manufactured by joining steel plates using tungsten inert gas ("TIG") welding or brazing. In this case, it is easy to form pin holes in the joins. Penetrating through holes leak outgas to the outside of the can. For example, even if there are no pin holes passing through, it is necessary to expel air and welding gas that builds up inside the pin holes.

The object of the present invention is to provide a coreless linear motor having a plurality of coreless coils housed air-tightly inside a can.

Another object of the present invention is to provide a coreless linear motor having a plurality of coreless coils housed inside a can having no danger of gas accumulating.

Disclosure of the Invention

In order to achieve the above described object, a can is manufactured without welding or brazing.

According to the present invention, a coreless AC linear motor comprises,

a magnet assembly forming a magnetic gap (**3**),

a can (**10**) including a coil housing section (**10F**) having a deep groove (**10B**) formed by gouging out material,

a plurality of coreless coils (**5**) inserted into the deep groove and arranged in a straight line inside the magnetic gap, and

a cover body (**11**) for sealing the can.

The material is preferably stainless steel.

Preferably, the can includes a flange section (**10A**) which is joined to the cover body and wider than the coil housing section.

An O-ring (**12**) for sealing between the can and the cover body in an air-tight manner is provided, and a seat (**10C**) for receiving the O-ring is formed in the flange section.

The deep groove is preferably rough machined using an end mill or drill, and finished using an electric discharge machining electrode. In this way, the deep groove is formed with high precision and efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front elevation of a coreless AC linear motor of the present invention.

Fig. 2 is a side cross section of the linear motor viewed along the line **A - A** in Fig. 1.

Fig. 3 is a plan view of the linear motor viewed along the line **B - B** in Fig. 2.

Fig. 4 is a plan view of a coil assembly of Fig. 1 housed in a can.

Fig. 5 is a front elevation of a magnet assembly of Fig. 1.

Fig. 6 is a plan view of the magnet assembly of Fig. 5.

Fig. 7 is a side cross section of the magnet assembly viewed along the line **C - C** in Fig. 6.

Fig. 8 is a plan view of a manifold of Fig. 1.

Fig. 9 is a side view of the manifold of Fig. 8.

Fig. 10 is a front elevation of the manifold viewed from **J** of Fig. 9.

Fig. 11 is a cross section of a cooling pipe viewed along the line **K - K** in Fig. 9.

Fig. 12 is a front elevation of a can of Fig. 1.

Fig. 13 is a side cross section of a can viewed along the line **D - D** in Fig. 12.

Fig. 14 is a bottom view of a can of Fig. 12.

Fig. 15 is a side cross section of a can viewed along the line **E - E** in Fig. 13.

Fig. 16 is a side cross section of a can viewed along the line **F - F** in Fig. 13.

Fig. 17 is a front elevation of a cover body of Fig. 1.

Fig. 18 is a partially cut-away side view of the cover body of Fig. 17.

Fig. 19 is a bottom view of the cover body of Fig. 17.

Fig. 20 is a cross section of the cover body viewed along the line **G - G** in Fig. 17.

Fig. 21 is a cross section of the cover body viewed along the line **H - H** in Fig. 17.

Fig. 22 is a cross section of the cover body viewed along the line **P - P** in Fig. 17.

Fig. 23 is a front elevation of a block of Fig. 2.

Fig. 24 is a side cross section of a block viewed along the line **L - L** in Fig. 23.

Fig. 25 is a front elevation of current introduction terminal of Fig. 2.

Fig. 26 is a cross section of the current introduction terminal viewed along the line **M - M** in Fig. 25.

Fig. 27 is a cross section of the current introduction terminal viewed along the line **N - N** in Fig. 25.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A canned coreless AC linear motor of the present invention will be described in detail with reference to the drawings.

A canned coreless AC linear motor comprises a coil assembly including a primary side armature, and a magnet assembly including a secondary side field magnet. The coil assembly contains a plurality of flat three phase coreless coils **5**, and moves in a sideways direction in Fig. 2 and Fig. 3 with respect to the magnet assembly. The coils **5** are arranged in a magnetic gap **3** in a movement direction in the order U-phase, V-phase, W-phase. In order to increase coil density, each coil **5** is overlapped on another coil. A coreless coil **5** is formed by winding 76 turns of enamel plated copper wire of φ 0.44 mm on a temporary frame having a cross section of 17 x 50 mm. When the temporary frame is pulled out, there remains an empty space corresponding to a through hole **5A**. A plurality of cooling pipes **7** pass through all of the through holes **5A** extending in a movement direction, while contacting the inner surface of each coil **5**. One end of a cooling pipe **7** is connected to a manifold **8**, while the other end is connected to a manifold **9**. A coil **5**,

manifold **8**, manifold **9** and cooling pipes **7** are integrated by enclosing these parts in a box, and filling the box with epoxy resin or adhesive **6**. The epoxy resin is hardened to form a coil assembly covered with resin. The formed resin block is finished so that the coil assembly can form an appropriate air gap with respect to permanent magnets **31** and **32**. With this embodiment, the thickness of the coil assembly is 8 mm in the magnetic gap **3**. The coil assembly is housed inside a can **10** that is thin, and the can **10** is sealed with a cover body **11**. As shown in Fig. 1, Fig. 2 and Fig. 4, an O-ring **12** seals between the can **10** and the cover body **11** in an air-tight manner. The coil assembly, can **10** and cover body **11** are integrated by filling additional resin into the can **10**.

As shown in Fig. 5, Fig. 6 and Fig. 7, the magnet assembly includes spaced side yokes **1** and **2**, a center yoke **4**, and a plurality of permanent magnets **31** and **32**. A pair of side yokes **1** and **2** are arranged parallel to each other, and are connected by the center yoke **4**. One row of permanent magnets **31** are attached on the side yoke **1**, while another row of permanent magnets **32** are attached on the side yoke **2**, and a magnetic gap **3** is formed between parallel rows. Magnetic poles of the permanent magnets **31** change alternately.

As shown in Fig. 8, Fig. 9, Fig. 10 and Fig. 11, with this embodiment seven cooling pipes are aligned in the direction vertical to the movement direction. A cooling pipe **7** has an outer diameter of 4 mm in the vertical direction, a thickness of 0.5 mm, and a length of 250 mm. As shown clearly in Fig. 11, adjacent

flat cooling pipes **7** are separated by a small gap **d** of 0.5 mm in order to prevent the flow of eddy currents. Passages **8A** and **9A** extending vertically respectively pass through the manifolds **8** and **9** in order to distribute cooling medium to the cooling pipes **7**. Cooling medium is sent from the passage **9A** through the cooling pipes **7** to the passage **8A**. The manifolds **8** and **9** respectively have brim sections **8C** and **9C** for connecting to the can **10**. The cooling pipes **7** are connected to the manifolds **8** and **9** by silver brazing or TIG welding. The manifolds **8** and **9** and the cooling pipes **7** are made from austenitic stainless steel defined by JIS (Japanese Industrial Standards) SUS300 (Cr-Ni) or JIS SUS200 (Cr-Ni-Mn). This austenitic stainless steel is non-magnetic, has excellent corrosion resistance and heat resistance, and has better mechanical strength than Al alloy or copper alloy.

The can **10** will be described in detail with reference to Fig. 12, Fig. 13, Fig. 14, Fig. 15 and Fig. 16. As shown in Fig. 15 and Fig. 16, the can **10** is comprised of a coil housing section **10F** and a flange section **10A**, and has a T-shaped cross section. The coil housing section **10F** has a deep groove **10B** that is thin and long. The deep groove **10B** has a width of 8.5 mm, a depth of 70 mm, and a length of 280 mm. The coil housing section **10F** has a width of 12.5 mm, a depth of 80 mm, and a length of 295 mm. The thickness of a side wall of the coil housing section **10F** is 2.0 mm. The flat coils **5** and the flat cooling pipes **7** are inserted into the deep groove **10B**. The flange section **10A** is wider than the coil housing section **10F**, and is joined to the cover body **11**. A recess **10E** formed in the flange section **10A** receives brim

sections **8C** and **9C** of the manifolds, and the manifolds **8** and **9** are fixed to the can **10** using bolts. A plurality of bolt holes are formed in the upper surface of the flange section **10A** in order to fasten the cover body **11** to the can **10**. A seat **10C** for receiving the O-ring **12** is formed in the flange section **10A** along the edge of the recess **10E**. The surface of the seat **10C** is polished in the direction of arrow marks in Fig. 12.

The cover body **11** for closing off the can **10** will be described in detail with reference to Fig. 17, Fig. 18, Fig. 19, Fig. 20, Fig. 21 and Fig. 22. The arrow marks in Fig. 19 represent a polished surface. The cover body **11** is joined to the upper surface of the flange section **10A**, and fastened to the can **10** using a plurality of bolts. A recess **11A** for housing a terminal block **13** is formed in a lower part of the cover body **11**. Lead lines of the coils **5** pass through the terminal block **13** inside the recess **11A**, and are taken to the outside of the cover body **11** from a hole **11B**. A seat **11C** for receiving the O-ring **12**, corresponding to the seat **10C** of the can **10**, is formed in the cover body **11**. After the can **10** has been sealed using the cover body **11**, resin or adhesive **6** is injected from a hole **11E** of the cover body **11**. A pair of joints **17A** and **17B** capable of connecting flexible pipes are attached to an upper surface of the cover body **11**. A passage **11F** communicating with the joint **17A** and extending in the horizontal direction, a passage **11G** connecting the passage **11F** to the passage **9A**, and a passage **11H** connecting the passage **8A** to the joint **17B** are formed in the cover body **11**. The cover body **11** is joined to the brim sections **8C** and **9C** using the O-ring. Cooling medium flows from

the joint **17A**, through the passages **11F**, **11G** and **9A**, the cooling pipes **7** and the passages **8A** and **11H**, and is expelled from the joint **17B**.

Fig. 23 and Fig. 24 illustrate a block **14** attached in an air-tight manner to the cover body **11** using a suitable O-ring. The arrow marks in Fig. 23 represent a polished surface. The block **14** has an introduction passage **14A** communicating with the hole **11B**. Fig. 25, Fig. 26 and Fig. 27 illustrate current introduction terminal **15** attached in an air-tight manner to a front surface of the block **14** using a suitable O-ring. The current introduction terminal **15** includes U-, V-, W- and E-phase terminals. A vacuum flange **16** is fixed to the block **14**, and the current introduction terminal **15** is attached to the vacuum block **16** by silver brazing.

A method of manufacturing the can **10** in a highly accurate and efficient manner without brazing or welding will be described in the following. The can **10** and the cover body **11** are preferably made from free-cutting stainless steel defined by JIS SUS303, etc. Free-cutting stainless steel does not have variation in feeble magnetism due to cutting heat. Material of a can **10** made from this type of stainless steel was cut, and first of all a T-shaped cross section having a width of 12.5 mm for the coil housing section **10F** has been formed. Next, the seat **10C** and the recess **10E** were machined in the material, and a flange section **10A** has been formed. Finally, the deep groove **10B** of the coil housing section **10F** has been formed in the material. A deep groove having a width of about 8.5 mm and a depth of about 30 - 40 mm over its entire length was gouged out using an end mill attached to a milling machine

or a machining center. Since it was not possible to form a deeper groove using an end mill, a tool was changed from an end mill to a drill. Using the drill, thirty five holes having a depth of 70 mm and a diameter of 7.5 mm were drilled about 8 mm apart along the entire length of the deep groove. TThe material was fixed to an electric discharge machine, and the deep groove **10B** was formed using an electrode tool made of copper or graphite having a complementary shape to the deep groove. A surface of the deep groove **10B** is preferably finished to a roughness of 32 μRmax. An electric discharge machined surface of this roughness had varying unevenness, and so the coil assembly was simply fixed to the can using resin or adhesive **6**.

This embodiment has been selected simply to describe the gist and practical application of the present invention. Various improvements are possible with reference to the above description. The scope of the present invention is defined by the appended claims.